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The Development and Implementation of the Skilled Projection for Enlisted Retention (SKIPPER) Community Management Model

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13. ABSTRACT *(Maximum 200 words)*

This report describes the enlisted community management model used to determine specific, community-level accession, training and advancement plans. The model provides projections by fiscal year, length of service and paygrade for up to eight years into the future. The current operational version is the second generation management model developed for BUPERS. Future versions will include additional enhancements as well as a merger with an existing sea/shore rotation model.

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Foreword

This report was prepared as part of the Modeling & Information Advances for Enlisted management project. It was sponsored by the Chief of Naval Personnel (N13). The objective of the work unit was to develop enlisted community management modeling tools for enhanced personnel inventory management, accession and advancement planning.

This report contains an overview of the development and of the Skilled Personnel Projection for Enlisted Retention (SKIPPER) model as well as a technical description of the model's capabilities.

Murray W. Rowe
Director

Executive Summary

Background

As evidenced over the past fifteen years, the Navy rarely experiences extended periods of "steady-state" force structure sizing. In the decade of the 80s, the Navy, Congress, and the Administration envisioned a 600-ship Navy. Ambitious shipbuilding programs were undertaken requiring personnel planners to begin the process of accessing, training, promoting, and retaining a force structure of more than 600,000 personnel. In the early 90s, with the fall of the Soviet Union, the 600-ship premise lost favor and downsizing, or as favored by the Navy—rightsizing, began. Personnel planners were then confronted with reducing personnel strength to nearly half of the 600-ship personnel requirement. These two examples illustrate the necessarily flexible nature of personnel planning within the Navy. Personnel planners recognized during the 80's buildup that better, more flexible models were needed to develop more accurate accession, training, and promotion plans to deal with both large and small inventory excursions.

Objective

The objective of this effort was to develop a robust continuation-rate model at the skill level of detail (rating/Enlisted Management Community (EMC)) that would be capable of dynamic expansion and contraction. For example, a (skill) x (paygrade) x (years of service) model could expand to include the sea/shore dimension or contract to just a (skill) x (paygrade) model.

Approach

The use of intelligent graphical user interfaces, expert systems, optimization techniques, and n-dimensional arrays were incorporated in the model development. Older, less user-friendly models were used as entering baselines. A basic graphical user interface (GUI) approach was initially overlaid on an existing model and then dimensional expansions were incorporated. The final stage will be to include the sea/shore dimension.

Results

The model, Skilled Projection for Enlisted Retention (SKIPPER II), is now in use by all enlisted community managers in N13. This provides consistency of analysis and is easily integrated into aggregate all-Navy planning.

Conclusion

The development of this model has significantly enhanced the community managers' ability to cope with planned inventory excursions. It has also provided the capability to determine the effect of alternative policies on future personnel inventories.

Recommendation

The planned enhancements to the model should proceed as planned.

Contents

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Introduction

Problem

This report describes the design, development, and implementation of a computerized, linear, algorithmic model to improve the Navy's ability to estimate enlisted personnel inventories by skill groupings, paygrades, and gender to arrive at defensible Navy personnel requirements. Enlisted Community Managers (ECMs) in the Bureau of Naval Personnel (BUPERS) are responsible for the management of their respective communities to include determination of the number of recruits required annually, the amount and type of training needed, promotion plans, and sea/shore rotation planning.

In the past, a number of different methods were used to develop these plans. Some ECMs developed complicated spreadsheets and analyzed past retention statistics to develop their plans. Others simply used "passed down" rules of thumb to make a best guess. Rarely, did two ECMs use the same methods. This resulted in virtually no consistency in plan development. Inaccurate plans resulted in personnel shortfalls or excesses requiring corrective action that was generally based on the same faulty process that had initially created the problem. When community inventory histories are reviewed, one frequently finds pronounced, erratic, up-and-down inventory excursions that rarely match requirements.

There are many forces at work in each enlisted community. Changes in billet structures have far-reaching impact on the sea/shore rotation, that in turn can have positive (or negative) effect on retention. This impacts accession plans, training plans and promotion plans. An ECM's ability to counter negative sea/shore rotation policy is directly related to his/her ability to justify the necessity for increased enlistment and reenlistment bonuses.

ECMs must be able to accurately assess the current and future inventory of enlisted personnel in their respective communities under alternative policy scenarios. The Skilled Personnel Projection for Enlisted Retention (SKIPPER) community management model assists the ECMs in determining the effect of policy alternatives on future personnel inventories.

Background

Numerous efforts have been undertaken to develop modeling tools to better support enlisted community managers. In the early efforts, slow computer speeds and mass storage limitations as well as rather limited and elementary computational algorithms hampered these tools. Efforts such as Accession Gaming Model (AGAM)[1] employed linear goal programming as the principal mathematical technique and used the IBM

[1] NPRDC Technical Report 80-32 of August 1980

Mathematical Programming System (MPSX/370) to solve the linear programming model. A follow-on effort, Optimal Accession Requirements (OAR)2 model, also used linear goal programming to minimize a weighted sum of surpluses and shortages from the desired goals. This model was developed on an IBM 3032 computer system using the same MPSX/370 programming system.

Over time, these models were revised and improved to their limits. With improved computer capabilities and ever-increasing and less expensive storage, models such as SKIPPER were more easily developed and adaptable to deployed network systems within BUPERS.

Approach

Assumptions

The following assumptions were made in the design of SKIPPER II:

- In the "A" School optimization segment of SKIPPER, the default assumes any near year value is worth more than all future years combined. An ECM can change this default.
- Individuals do not become part of the community until they have completed "A" School training.
- SKIPPER uses a "frocked" begin inventory (BI). This means that an individual selected for promotion to the next highest grade, but not yet actually advanced is counted in the grade for which selected.
- Continuation rates are length of service (LOS) based. Individuals in a particular LOS behave the same regardless of paygrade (except in the case of high year tenure).
- The advancement algorithm assumes a vacancy driven, carry down approach.
- The model assumes that individuals "at risk," or at a reenlistment decision point are affected by Selective Reenlistment Bonuses (SRBs). SRBs are not modeled directly. At Risk Continuation Rates may be modified to reflect the expected effects of changes in SRBs.
- Advancements are determined after losses. The model assumes that an individual that advances will continue in the service.
- There are no time-in-grade restrictions, only time-in-service constraints are applied to the advancement element of the model. An individual cannot advance two grades within one year.

[2] NPRDC Technical Report 80-33 of September 1980

- There are waivers of eligibility applied in actual execution of advancements. The model however, does not apply any such waivers.
- One of the simplifying assumptions made in SKIPPER is that members always advance within their family.

Method

Personnel Modeling

SKIPPER II models enlisted end strength and personnel flows using Simplex linear programming. It uses historical data to forecast future inventories and flows. This data is generated quarterly and aggregated with the following dimensional detail, although not all dimensions are present for every kind of data:

1. Skill, to identify enlisted management communities, clusters, competitive categories, ratings, and all-Navy categories.
2. Length of Service
3. Paygrade
4. Gender (females only, or both males and females together)
5. Demographic group (African-Americans, Hispanics, Asian-Pacific Islanders)
6. (Numbers 4 & 5 are currently generated on request only.)

The data is discussed in detail in the following section.

Forecast calculations are made for families of skills. Two skills are in a family if the skill classification of members switches from one skill to the other as they advance. Each skill is modeled as belonging to one family only.

The forecast calculation starts with actual inventory counts (Appendix A). Paygrade counts are adjusted to reflect demotions (Appendix B). Then it subtracts losses (Appendix C) based on the continuation rates (Appendix D). Then it ages the inventory. Then it adds gains (Appendix E) input by the manager. Then advancements (Appendix F) are calculated for each paygrade using an algorithm that fills vacancies (the difference between the target inventories and projected inventories without advancements) (Appendix G). The advancements are then distributed among the LOS cells and added to the end inventory. The forecast for the next time interval then uses the end inventory from the previous interval as its begin inventory. Forecasts are made for ten fiscal years, or for two advancement cycles.

Data is displayed primarily in two spreadsheets. The inventory sheet shows three historical inventories in addition to the forecasts, including counts for the end of the last two fiscal years, and the most recent quarter. Initial display includes counts for each

Selective Retention Bonus zone. By clicking on various buttons the manager may display data with LOS detail, paygrade detail, and full LOS by paygrade detail.

The gains sheet is where managers develop accession plans. School input may be specified for two pipelines: four-year obligatory A-School and six-year obligatory A-School. A-school input may be broken into CNRC accessions, fleet input, Job Oriented Basic Skills (JOBS) input, College Fund input, Navy Training System Plan (NTSP) input, miscellaneous input, and input to the Targeted A-School Program (TASP) program. Various buttons will hide or reveal detail by sub-category and gender (male, female, both). As the manager develops the schools input plan, displays showing the resulting school graduates are immediately calculated and displayed.

The Data

Managers do not need to know anything about how SKIPPER data is produced or maintained in order to use the system. However, an understanding of the contents of the data--what the numbers actually represent—is necessary to appreciate the significance of user inputs and model results, and the means by which policy decisions may be represented with data overrides.

The historic data used to estimate future personnel flows is generated at the end of each fiscal quarter. Each database replaces the previous database. The database consists of a set of over 40 DBASE files. Each DBASE file contains data of a particular type for all the skills. Female and demographic data are stored in separate files whose structure is identical to the corresponding files for the aggregation. Female & demographic data are stored as separate subsets in the same files used for the aggregation. So each datakind, e.g. End of Active Obligated Service (EAOS) rates, has only one historic data file.

Almost all of the data comes from Navy Enlisted Master Record (EMR) files. EMR files have records for individual enlisted members. During generation of the database, EMR records are matched by social security number (SSN) across different time points, and then accumulated to produce aggregated counts defined by the intersection of skill, LOS, paygrade, and/or gender and other dimensions. For example, a Sailor (identified by SSN) may be in the Electronics Technician—Submarines (ETSS) community at time point 1, and in ET—Surface Warfare (ETSW) at time point 2. Then he or she is counted as a loss (non-continuation) for ETSS, and a gain (non-school gain) for ETSW.

Testpasser data is produced based on counts in files provided by Navy Testing Program Management Support Activity. Enlisted Personnel Authorized (EPA) data is based on files provided by Chief of Naval Operations (CNO) (N12). These files include data for Enlisted Management Communities only. The EPA is then aggregated to provide EPA for clusters and competitive categories. Official rating level data is not currently available, so user overrides of EPA are necessary to model ratings.

Data is aggregated with some or all of the following dimensional detail:

1. Skill, for communities Enlisted Management Community (EMC), clusters, competitive categories, and ratings

   - Four levels of skill classification are available in SKIPPER: Enlisted Management Community, ratings, clusters, and competitive categories. Some skills are both EMCs and competitive categories. Also, some skills are both clusters and competitive categories. Several all-navy groupings (e.g., ALNAVMPN, ALNAVRPN) are also in the SKIPPER database. These groups may be modeled exactly as if they were skills.

   - Enlisted Management Communities (EMC). A member's EMC is identified using an algorithm based on the member's rating and other data fields.

2. Length of Service (LOS)

   - Length of service is computed based on an individual's total active federal military service (TAFMS) on the date of the inventory snapshot. The active duty service date (ADSD) EMR field is used.

   - An individual with less than one year of service at that time is in LOS 1, an individual with more than one year of service but less than two years of service at that time is in LOS 2, etc. The maximum LOS is 31; members with more than 31 years of service are included in the LOS 31 cells.

3. Paygrade

   - Paygrade is defined as "B3" for "bottom three" (E1 - E3), E4, ... E9. The PRES-RATE-CODE-PG EMR field is used.

4. Gender (females only, or both males and females together).

   - SKIPPER data files either hold data for both genders together (aggregate counts) or females only. Male-only data does not exist, but may be calculated if necessary as: Male = Both - Female.

5. Demographic Group (i.e., blacks, Hispanics, Asian-Pacific Islanders)

   - SKIPPER data files either hold data for all the demographic groups combined, or either Asian-Pacific Islanders, Blacks, or Hispanics only. Continuation rates are computed differently for the demographic groups, due to the concern over "small number" problems. Rather than using only the skill's demographic inventory as a base for computing continuation rates, the demographic inventory for the entire DOD occupational group is used.

Data includes one or more files for each of the following:

1. Inventory

   - Inventory counts by skill, LOS and paygrade are present in the SKIPPER database for three time periods: the end of the last fiscal year, the end of the previous fiscal year, and the end of the most recent quarter.

- The database also includes percentages that divide the inventories into individuals who are "at-risk" or "not-at-risk." A member is at-risk if his or her hard EAOS date is within the 12 months following the date of the inventory snapshot. Otherwise, the member is considered not-at-risk.
- Forecasts gain accuracy by dividing inventory by risk category and LOS, because at-risk continuation rates tend to be substantially lower than not-at-risk continuation rates. Gains in accuracy are especially significant for the first term of service, since for many skills initial enlistments are for fixed lengths of time.
- EAOS percentages have the LOS dimension only.
- Note that paygrade is not used in computing continuation rates or EAOS percentages.
- The model also uses High Year Tenure Continuation Rates (HYT CR). Inventory in the HYT zones is excluded when generating continuation rates. An additional HYT continuation rate vector is created that is based entirely on the HYT zone inventory. This vector is applied selectively by PG on top of the normal continuation rates.

2. Enlisted Personnel Authorized (EPA)
   - EPA data is based on files produced by PERS-05. Machine-readable EPA are produced for EMCs only. The data is then aggregated to provide EPA for clusters and competitive categories. There is no EPA for females or any of the demographic groups.
   - The EPA data file includes five columns for five fiscal years, starting with the current fiscal year. Since SKIPPER forecasts 10 fiscal years, the fifth year of EPA is also used for forecast years six through ten.
3. Continuation rates
   - Continuation rates represent the propensity of an individual who starts the year in a particular skill, with a particular amount of experience (LOS), with a particular status (at-risk/not at-risk), and with a particular gender (female/aggregate) (or demographic group) to be in that same skill one year later. At-risk continuation rates are used to estimate non-reenlistment. Not-at-risk continuation rates are used to estimate attrition. If the member has advanced into a new skill in the family, he/she is still counted as continuing.
   - This computation is done on an individual basis (by social security number match), and will therefore always be less than one (100%), and will be unaffected by gains into the skill during the year. Two EMR files are used: the most recent EMR, and the EMR from 12 months prior.
   - Continuation rates have the skill and LOS dimensions, but not the paygrade dimension. One of the reasons for not estimating rates by LOS and paygrade is the "small numbers" problem. Estimates are statistically unreliable when they are

based on just a few cases. Even without the paygrade dimension, managers will note that rates for the upper LOS tend to be "rough." For example, for LOS 28 an at-risk rate might be 100%, 0% for LOS 29, and 50% for LOS 30. This is because the estimates are based on inventory counts of just one, two, or even zero members. Generally this inaccuracy does not have a significant effect on forecasts, exactly because the inventory affected is very small.

4. Gains

   - The SKIPPER database includes historical counts of school and non-school gains. An SSN that was not in the same skill in the EMR 12 months prior, is considered a gain to the skill. Gains who have first entered the Navy (strength gains), or who changed their skill classification (skill gains) are not distinguished. However, members who advance from one skill into another skill within the same family are not considered gains.

   - Historic gains data are used to distribute the total gains entered by managers on the gains sheet into LOS and paygrade detail. The size of the gains counts themselves do not matter, therefore, only their distribution does. The data is stored by LOS and by paygrade separately (31 + 7 numbers rather than 31 * 7). School Gains are stored with LOS by PG detail (31*7).

   - Because the EMR does not have information that directly identifies gains as school or non-school, an algorithm is required to impute the type of gain. If the member's paygrade is greater than E5, or the LOS is greater than eight, he/she is considered a non-school gain. If the paygrade is E5 and LOS is greater than three, he/she is also a non-school gain. If the member is a strength gain, or had a duty type of Individual Account (IA) during the 12-month interval, he/she is considered a school gain. Otherwise, he/she is considered a non-school gain. The EMR transfer date and first past accounting code are used to identify members who were IA in between the EMRs at the beginning and end of the 12 month interval.

   - One of the simplifying assumptions made in SKIPPER is that members always advance within their family. In reality, advancement is sometimes combined with a lateral movement. In particular, many members advance out of B3 training skills into other skills that are not modeled as the same family. For this reason, two other kinds of data are included in the databasethat measure the overlap between gains and advancements. Advancements are identified as members who are in both EMRs (12 months apart) and whose paygrade is higher in the latter EMR. The rate authorization is then used to identify examined advancements into E4 which are also gains; these advancements are "backed out" by the model before it determines how many advancements are required using the vacancy driven algorithm (see Advancements).

5. Advancements

- Since SKIPPER is used for advancement planning, advancement data is accumulated with a substantial amount of detail. The database includes separate files for examined/prospective advancements, selectee advancements, automatic advancements, and miscellaneous advancements:
- Since SKIPPER uses frocked inventory, Prospectives and Selectees are not modeled.

(1) Examined/prospective. This data file combines examined Sailors who have actually advanced (promoted), and members for whom examined advancement is planned for a particular date. Data includes the skill, LOS and paygrade dimensions, and also a fiscal year/fiscal month dimension, making it by far the largest data file in the database (actually larger than all the others combined). The fiscal year/month dimension is required to use the data accurately for planning advancement cycles.

Actual advancement is recognized by a member being in both EMRs (the begin fiscal year and the most recent quarter) with a higher paygrade in the latter. The rate authorization field is used to identify examined advancements (those actually promoted).

Prospective (pending) advancement is recognized by the presence of the prospective rate date field. Prospectives more than six months old which have not actually advanced are considered to be expired.

For simulating advancement cycles, the model needs to know the date through which prospective advancements have already been planned. In the data there are frequently a small number of "stray" prospective advancements for dates in the future of Navy-wide prospective planning. These are ignored by the system. The cutoff month is the last month with more than 20 prospectives planned.

Databases for the end of the fiscal year (September) or December will include data for the previous fiscal year up through the cutoff month. March and June databases include prospective data only for the current fiscal year.

(2) Selectees. These are members who have been chosen for advancement, but the exact date within the advancement cycle has not yet been set. The data is detailed by skill, LOS, and paygrade.

(3) Automatic advancements. These are identified by having a higher paygrade in the most recent EMR compared to the EMR 12 months prior; the new paygrade must be E4, and an appropriate rate authorization code must be present. Detail is by skill, LOS, and paygrade.

(4) Miscellaneous advancements. These are identified by having a higher paygrade in the most recent EMR compared to the EMR 12 months prior; and by having an appropriate rate authorization code. Detail is by skill, LOS, and paygrade.

6. Demotions

   - Demoted members are identified as those who have a lower paygrade in the most recent EMR than they did 12 months prior. Note that members who are demoted and restored in that time period will not be counted. The data is stored as rates (percentage of inventory demoted), detailed by skill and paygrade.

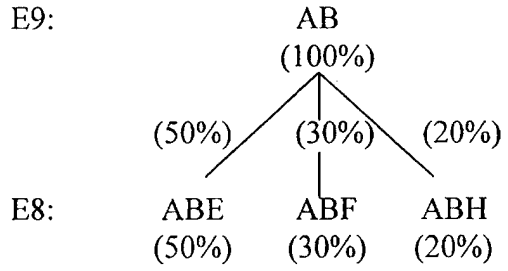
7. Testpassers

   - SKIPPER uses testpasser data in two forms. Testpasser counts into each skill are included in a database file (with skill and paygrade detail). Also, the family control table includes split-in percentages, which tell the model the proportions of advancements to move into a skill from other skills in the family.

   - Testpasser data comes from Navy Education and Training Program Management System Activity (NTPMSA), for each advancement cycle (E456, E7, and E89) as it occurs. Currently testpasser counts are not being produced for females or for ratings, although this data could be made available if it is required. Testpasser data for other skills that are not competitive categories is not available and would be difficult to obtain since tests are not administered for these skills.

   - Calculation of split-in percentages includes the following processing. First, all testpassers are counted using a data structure that represents both the source (out) and destination (in) skills. Then, source counts are divided by destination counts to produce the split-in percentages. Testpassers hoping to advance between skills that are not within a family according to the Family Table are "remodeled." In other words, they are treated as if they come partly from each of the source skills feeding the destination skill within the recognized family.

   Hypothetical Split-In Percentages for the AB Family



(5) SKIPPER forecasts for families of skills. Most skills constitute a family by themselves. Multi-skill families occur when movement across paygrades automatically implies movement from certain skills to other skills. In most cases this occurs when a skill does not exist at all paygrades. For example, the communities ABE, ABF and ABH exist for paygrades B3 through E8. Advancements out of E8 into E9 imply a change of membership into community AB. Likewise, demotion out of AB implies movement into

either ABE, ABF, or ABH. Various types of family "trees" exist: in some cases many skills flow into one; in others one skill breaks into many; and in others skills within a family exist at the same paygrades, but supply/receive large numbers of members from each other.

(6) Figure 1 illustrates the data structures used by SKIPPER to represent family structures. Each skill belongs to a family and points to each skill within it. Each paygrade of the skill may have a split-in, out, or both. Splits may contain multiple flows. The flow contains the quantitative data—the number of testpassers—and the split-in percentages that are calculated from these.

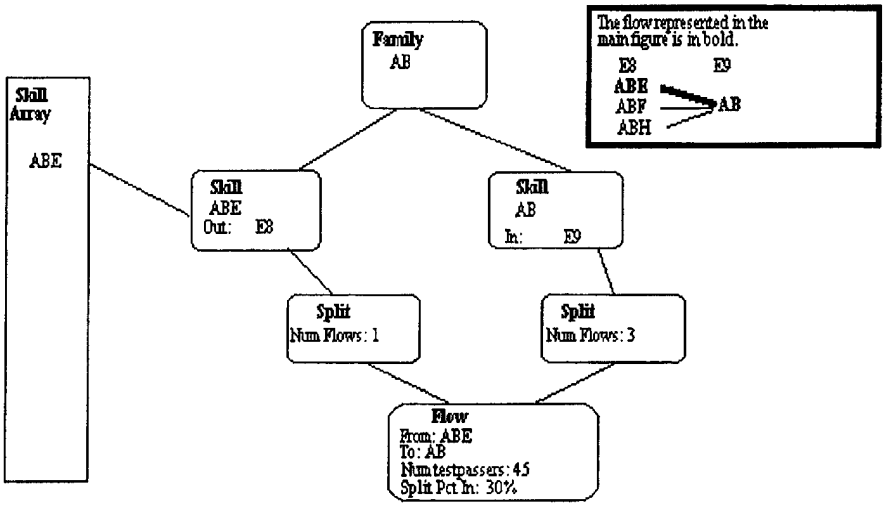


Figure 1. SKIPPER data structures used to represent family structures.

(7) The split-In percentages based on testpassers are used by the model wherever there is a flow across paygrades, including advancements, demotions, vacancies, net inventory constraints, and so on. When the flow is from the higher paygrade to the lower, split-out percentages are calculated dynamically using the split-in percentages and the counts for the data being transformed. In either case, data for a skill at one paygrade may be split into counts for several skills at the other paygrade, or counts for several skills may be accumulated into one count, according to the structure of the family.

(8) Note that SKIPPER's family data structures provide a faithful representation of the actual skill families except for one simplifying restriction: each skill can belong to only one family. Multiple flows between two skills at different paygrades are supported. Also, the vacancy-driven algorithm used for calculating advancements requires that families not have structures that "cross" (e.g., in which two skills flow into two skills, instead of one skill into two skills or two skills into one skill).

(9) Training skills contribute members to many other skills. However, they must be modeled as being in separate families because of the restriction that

a skill can only belong to one family. The method of reflecting laterals out of the training skills in SKIPPER is through the entry of non-school gains.

The Model

The inventory projection model underlying the current version of SKIPPER is far more elaborate than the previous version, because it includes a paygrade dimension and is used for planning advancements as well as accessions. In the previous version of SKIPPER almost all of the calculations were visible as formulas on the Excel spreadsheets (when formulas were displayed from Excel full menus). In the current version, most of the calculations occur in a C++ program, and are hidden to the user. In particular, calculations occur for families of skills, even though only one skill is displayed. However, a data inquiry capability can be used to inspect most of the model's intermediate results, including data for other skills in the family.

To provide both a comprehensive overview and an organized means for explication of the model's details, the simulation equations are presented in a hierarchical manner. The highest level equation yields End Inventory (Appendix A). The same equations are used for fiscal year and advancement cycle forecasts. The user can click on any part of the equations shown to learn more about how that element is calculated.

Advancements are automatically determined by the model with a vacancy-driven algorithm that simulates just enough advancements to meet target inventory. This procedure is discussed in a separate topic.

Several issues that relate only to advancement cycle forecasts are also discussed, including conversion of fiscal year data to advancement cycle data, aging of inventory in cycle forecasts, and testpasser carryover for paygrades other than those in the advancement cycle being planned.

The same program that calculates SKIPPER forecasts is also used to generate the advancement plan used by the advancement planner. This capability is meant to enable a two-way flow of information and dialogue between Enlisted Community Managers and the advancement planner. The Advancement Planning Tool (APT) model, with its many similarities and few differences from SKIPPER, is briefly discussed in a separate section.

Displays and User Input

Inventory Display

Figure 2 displays historic and projected personnel inventories. The projected personnel inventories are updated whenever a forecast is made. By default, the inventories are broken out by LOS zones only. The LOS button provides full LOS detail (see Figure 3).

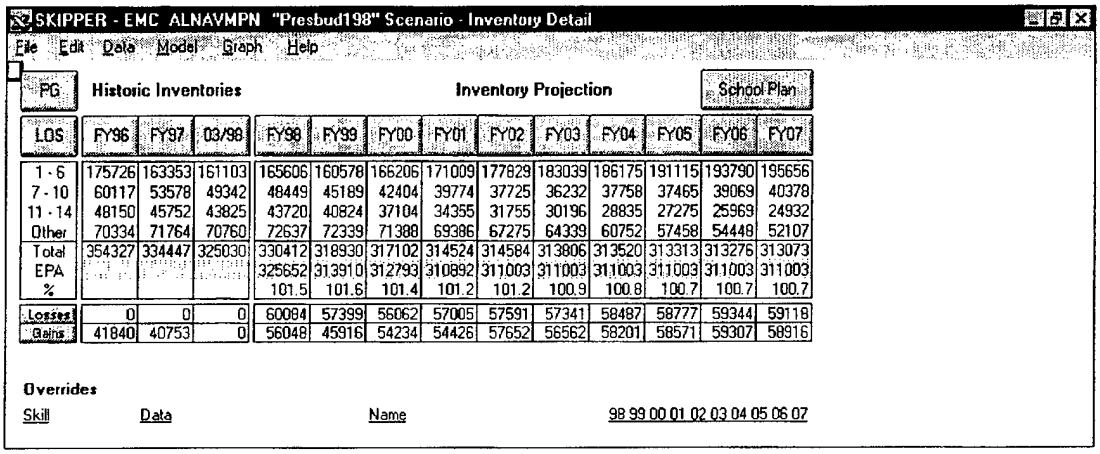


Figure 2. Historic and projected personnel inventories display

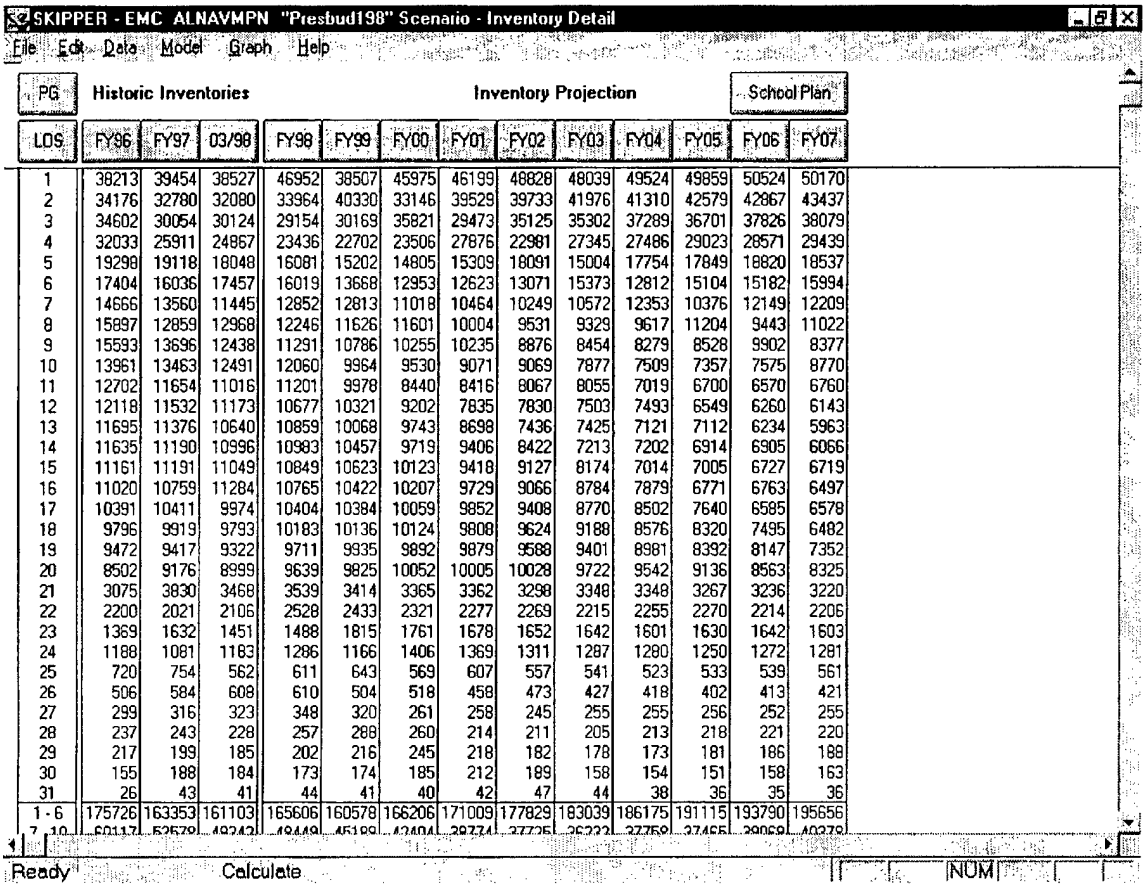


Figure 3. Full LOS detail.

The PG button provides a paygrade breakout (see Figure 4).

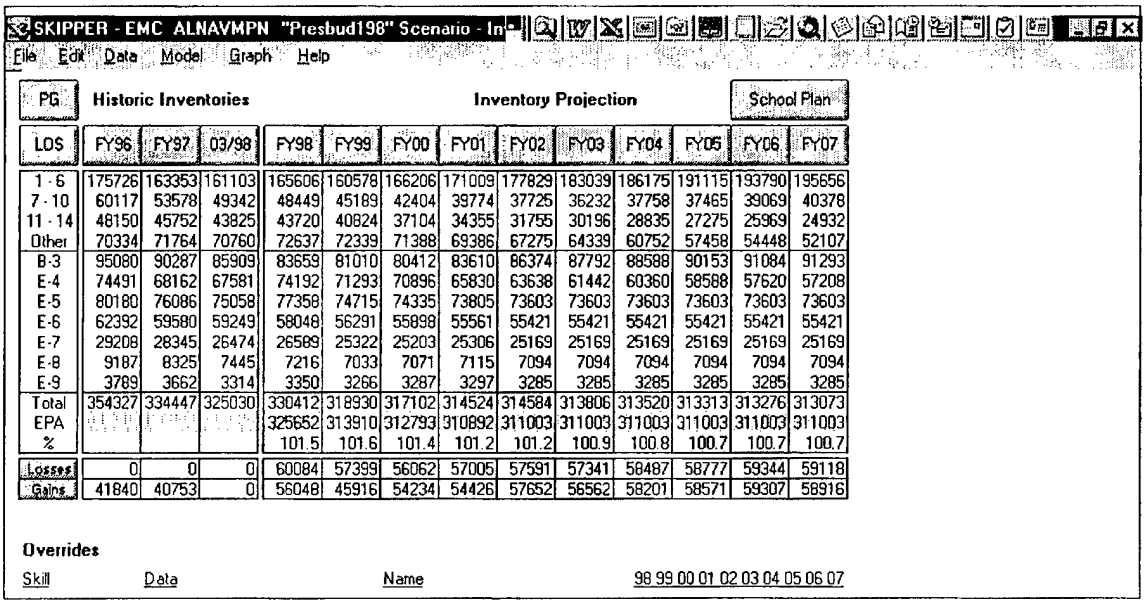
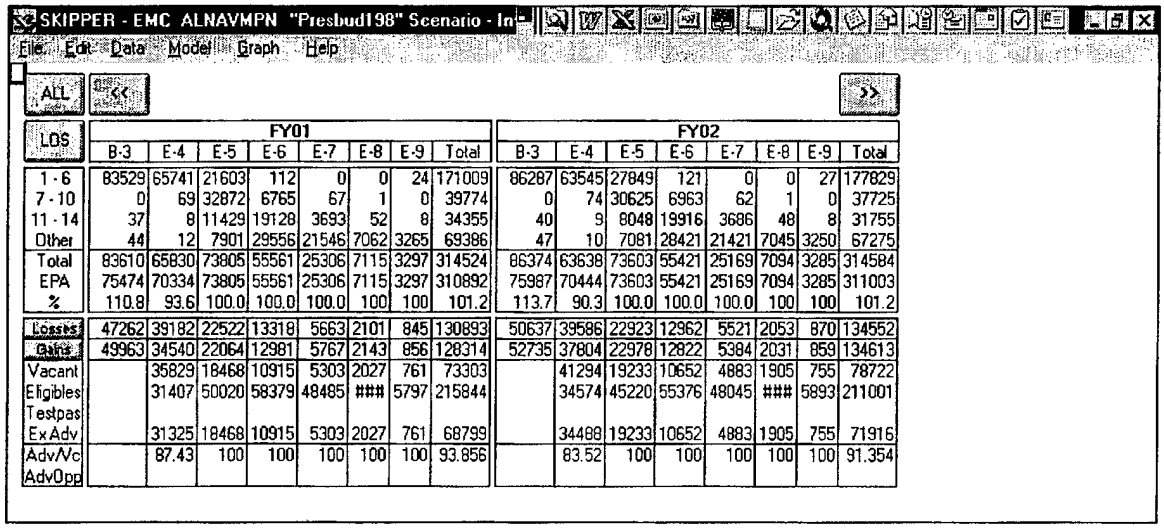


Figure 4. Paygrade breakout screen.

Clicking the small button located just above each FY column (labeled FYXX) displays a projected inventory with LOS by paygrade detail (see Figure 5).



	FY01								FY02							
	B-3	E-4	E-5	E-6	E-7	E-8	E-9	Total	B-3	E-4	E-5	E-6	E-7	E-8	E-9	Total
1 - 6	83529	65741	21603	112	0	0	24	171009	86287	63545	27849	121	0	0	27	177829
7 - 10	0	69	32872	6765	67	1	0	39774	0	74	30625	6963	62	1	0	37725
11 - 14	37	8	11429	19128	3693	52	8	34355	40	9	8048	19916	3686	48	8	31755
Other	44	12	7901	29556	21546	7062	3265	69386	47	10	7081	28421	21421	7045	3250	67275
Total	83610	65830	73805	55561	25306	7115	3297	314524	86374	63638	73603	55421	25169	7094	3285	314584
EPA	75474	70334	73805	55561	25306	7115	3297	310892	75987	70444	73603	55421	25169	7094	3285	311003
%	110.8	93.6	100.0	100.0	100.0	100	100	101.2	113.7	90.3	100.0	100.0	100.0	100	100	101.2
Losses	47262	39182	22522	13318	5663	2101	845	130893	50637	39586	22923	12962	5521	2053	870	134552
Gains	49963	34540	22064	12981	5767	2143	856	128314	52735	37804	22978	12822	5384	2031	859	134613
Vacant		35829	18468	10915	5303	2027	761	73303		41294	19233	10652	4883	1905	755	78722
Eligibles		31407	50020	58379	48485	###	5797	215844		34574	45220	55376	48045	###	5893	211001
Testpas																
ExAdv		31325	18468	10915	5303	2027	761	68799		34488	19233	10652	4883	1905	755	71916
Adv/Vc		87.43	100	100	100	100	100	93.856		83.52	100	100	100	100	100	91.354
AdvOpp																

Figure 5. Projected inventory screen with LOS by paygrade detail.

Each area of the INVENTORY spreadsheet is described below. User input areas are colored green and data which can be overridden is blue (refer to Figure 2).

(1) EPA - The vacancy-driven advancement algorithm is designed to meet paygrade EPA. Also, the School Inputs Recommendation module generates school inputs that produces inventory to meet EPA. The EPA line is also used as a denominator in the calculation of inventory divided by EPA.

(2) The historical both/female EPA are not protected and may be modified by the user if desired. If values are entered, the INV/EPA line will automatically be updated after recalculation to reflect these values. The SKIPPER spreadsheet contains two different EPA lines; EPA, and EPA-F. However only one of the EPA lines will be visible at a time. The EPA line will be displayed when the aggregate gender has been selected, the EPA-F line will be displayed when the female gender has been selected. To simplify the display, female breakout numbers are not shown on the Gains or Inventory details sheets. A separate female breakout sheet is provided & can be accessed from the Gains sheet. Female numbers can be modeled in a separate scenario.

- Inventory by LOS (an optional area) —Historical and projected inventory detailed by length of service. This optional area may be opened and closed by clicking the "LOS" button (refer to Figure 3).

- Inventory by PG (an optional area)—Historical and projected inventory detailed by paygrade. This optional area may be opened and closed by clicking the "PG Dimension" button (refer to Figure 4).

- Zoned Inventory Summary—Historical and projected inventory are totaled within the SRB zones.
- INV and % (of EPA) —These rows include the total historical and projected inventory counts, and the percentage of these totals in relation to EPA.
- There is also a % of EPA line that is displayed only when the EPA Adjustment Percentage is overridden.
- Gains & Losses breakout detail provided.
- Inventory by PG and SRB zone (optional areas)—Projected inventory with detail by paygrade and SRB zone. This optional area may be opened and closed by clicking one of the buttons above the forecast fiscal year at the top of the spreadsheet (see Figure 5).
- Inventory by PG and LOS zone (optional areas)—Projected inventory with full detail by paygrade and length of service. This data may be opened by clicking the "LOS Detail" button visible when already viewing PG/SRB zone data (see Figure 6).

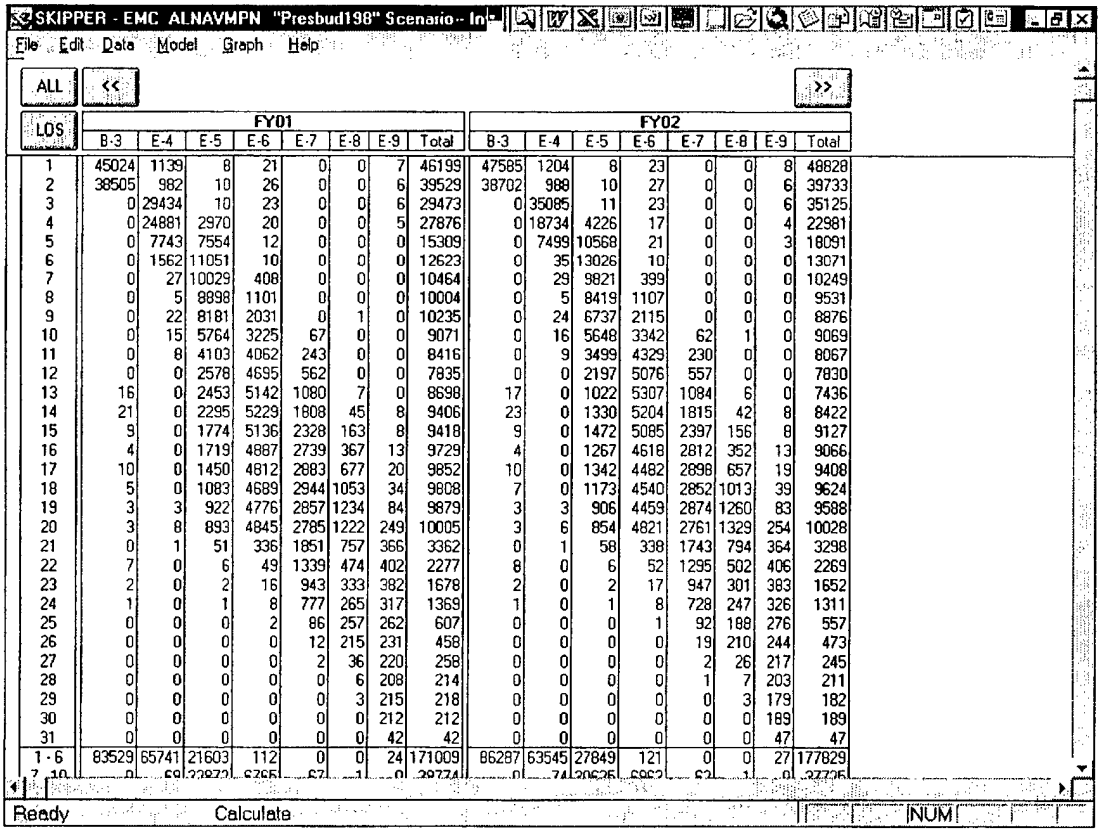
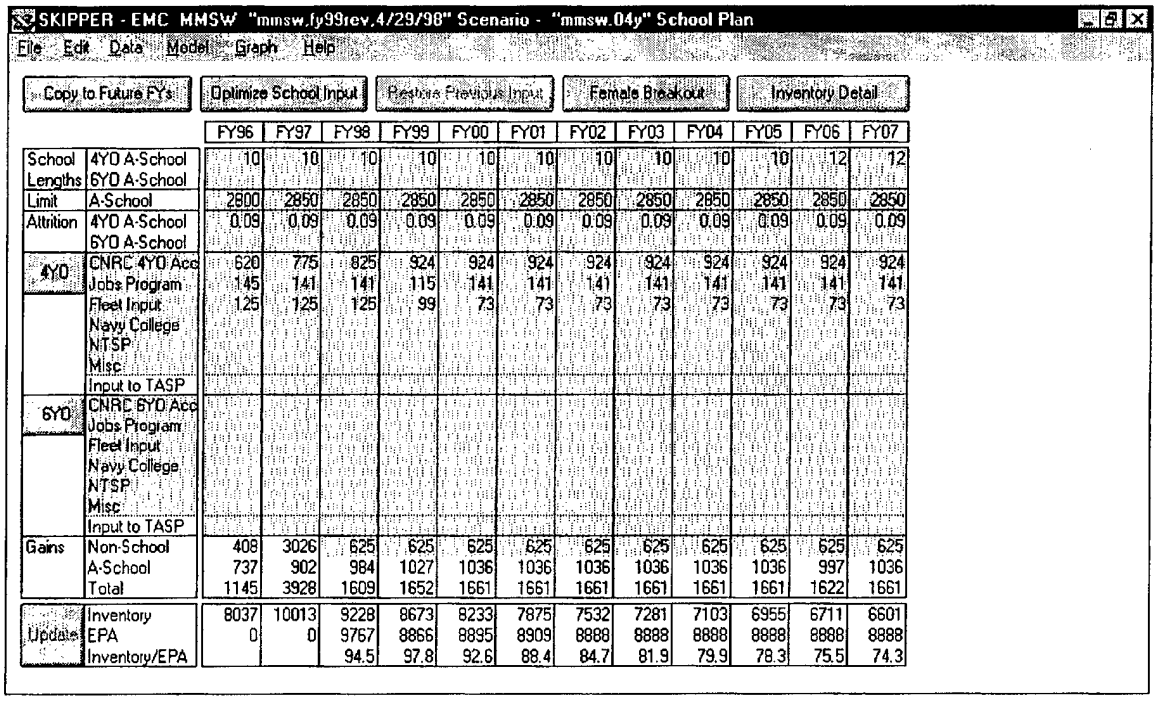


Figure 6. LOS detail.

Gains Display (see Figure 7)



		FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07
School Lengths	4YO A-School	10	10	10	10	10	10	10	10	10	10	12	12
	6YO A-School												
Limit	A-School	2800	2850	2850	2850	2850	2850	2850	2850	2850	2850	2850	2850
Attrition	4YO A-School	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	6YO A-School												
4YO	CNRC 4YO Acc	620	775	825	924	924	924	924	924	924	924	924	924
	Jobs Program	145	141	141	115	141	141	141	141	141	141	141	141
	Fleet Input	125	125	125	99	73	73	73	73	73	73	73	73
	Navy College												
	NTSP												
	Misc												
	Input to TASP												
6YO	CNRC 6YO Acc												
	Jobs Program												
	Fleet Input												
	Navy College												
	NTSP												
	Misc												
	Input to TASP												
Gains	Non-School	408	3026	625	625	625	625	625	625	625	625	625	625
	A-School	737	902	984	1027	1036	1036	1036	1036	1036	1036	997	1036
	Total	1145	3928	1609	1652	1661	1661	1661	1661	1661	1661	1622	1661
Update	Inventory	8037	10013	9228	8673	8233	7875	7532	7281	7103	6955	6711	6601
	EPA	0	0	9767	8866	8895	8909	8888	8888	8888	8888	8888	8888
	Inventory/EPA			94.5	97.8	92.6	88.4	84.7	81.9	79.9	78.3	75.5	74.3

Figure 7. Gains display.

This sheet is used for accessions planning. All cells with green background take user input. The total school and non-school gains are used for the inventory projection.

Each area of the GAINS spreadsheet is described below. Areas that accept user input are colored green. Data that can be or has been overridden appears in blue.

- School Lengths—The length of "A" School pipeline for 4YO and 6YO
- Limit - This line describes how many slots in A-School are available for the current EMC or rating. It is used as a constraint for the 4YO and 6YO school inputs.
- Limit—This line describes the maximum number of inputs that can be entered for the 4YO and 6YO pipelines combined.
- Attrition: 4YO A-School, 6YO A-School—Represents the attrition rate for each of the school pipelines. Ideally, this rate should be attrition up to the point at which the trainee is a member of the community. Attrition after this point is reflected in continuation rates within the community (i.e., the attrition has occurred after the individual has become a member of the community). School graduates are assumed to enter a community, on the average, halfway through the year. Therefore, six-months worth of weighted at-risk/not-at-risk continuation rates are applied to graduates in the year that they graduated.
- 4YO/6YO Entries: CNRC 4YO Accessions, Jobs Program, Fleet Input, Navy College Fund, NTSP, Misc, TASP—These are the 4YO A-School sources. They

are not used individually, but rather are summed up and used in the aggregate. They are broken out in this way for information purposes only.

Note that TASP input is treated differently from the other A-school inputs. There are two major differences: first, SKIPPER assumes that only 60% of the individuals who enter the TASP program will actually enter the targeted "A" school; and second, SKIPPER assumes that the lag time to enter school will be uniformly distributed between 18 and 24 months. The combined effect of these assumptions is that 15% of year one's TASP program start school in year two, 45% start school in year three, and 40% drop out of the program. For example, if you have 100 individuals entering TASP in FY-90, SKIPPER assumes that 60 of them will enter their targeted school (100 x 60%). Of these 60, SKIPPER assumes that 15 will enter in FY-91 (60 x 25%), and that the remaining 45 will enter in FY-92 (60 x 75%).

- Gains

  Non-School - This line represents all community/rating gains that come from a source other than the school pipelines. Examples of this type of gain are on-the-job (OJT) gains, prior service gains, and nuclear school pipeline dropouts.

  A-School—Not a user input. Shows the number of school graduates. These are a function of all elements of the school plan, including school inputs, attrition, length and loading.

  Total—Not a user input, but rather an information only line that allows the user to see what the total gains to the community are projected to be in the out-years, and to compare them to actual total gains in the prior fiscal year. The prior year's total gains are derived from historical data. Current and future years' total gains are computed by SKIPPER based on user input related to school and non-school gains to the community.

Historic and Future Continuation Rates:

Not-At-Risk continuation rates—The percent of inventory not at-risk which will be in the same EMC or rating the following year. (Note that these continuation rates are somewhat lower than All-Navy rates, which measure what percent of inventory will still be in the Navy the following year).

At-Risk continuation rates (Figure 8)—The percent of inventory at-risk which will be in the same EMC or rating the following year. (Note that these continuation rates are somewhat lower than All-Navy rates, which measure what percent of inventory will still be in the Navy the following year).

Percent of inventory at-risk (Figure 9)—The percentage of inventory in each LOS which is at-risk. An individual is considered to be at-risk if his EAOS (soft) is within the next 12 month period. The at-risk continuation rates are applied to inventory at-risk, and the not-at-risk rates are applied to personnel who are not at-risk.

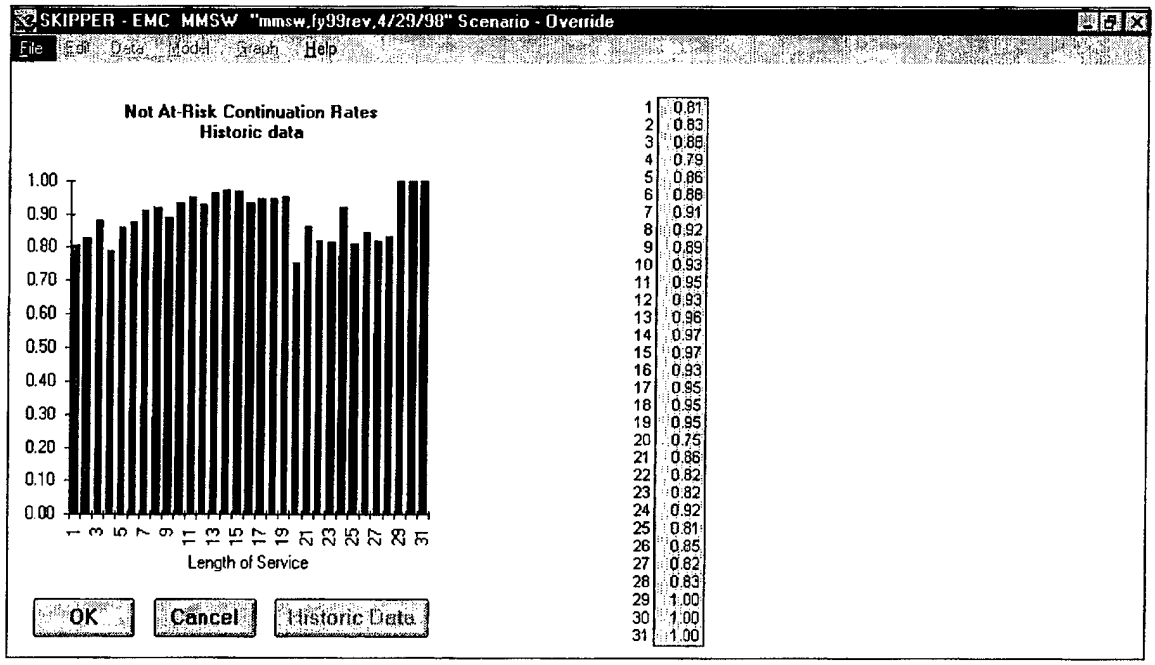


Figure 8. Not-AT-Risk continuation rates screen.

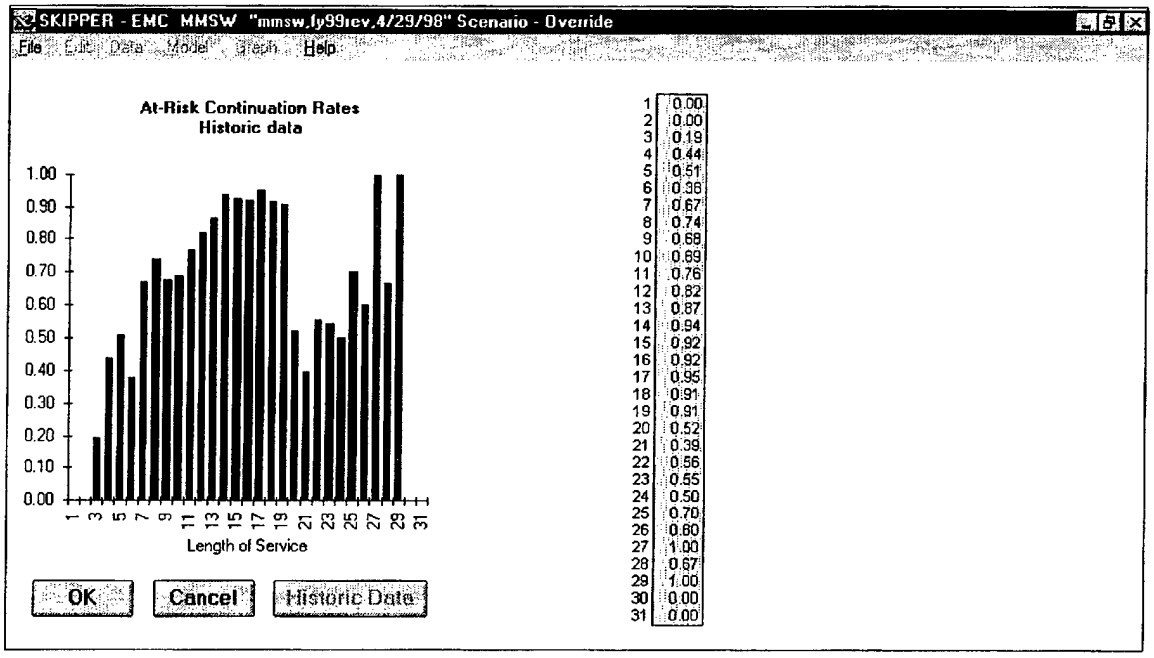


Figure 9. At-Risk continuation rates screen.

Advancement Planning Tool (APT)

The advancement planner to recommend advancements which best meet the inventory targets for each skill, while satisfying all-Navy constraints uses the Advancement Planning Tool (APT) model. APT uses the same forecasting engine as SKIPPER.

APT uses scenario-specific user input developed by Enlisted Community Managers for SKIPPER. This allows the APT forecast to be essentially identical to results obtained for the advancement cycle for individual families in SKIPPER—except for the effect of apportionment.

Apportionment is the process by which skill advancements are adjusted so that the desired all-Navy total is met. In apportionment, advancements are adjusted until the ratios of end strength over target inventory are the same for all skills, except for skills which are hitting either an upper advancement bound (all testpassers are used) or an advancement lower bound (token advancements).

SKIPPER Advancement and Testpasser statistics:

- Advancement Opportunity

  The Gains sheet automatically updates projected gains when the school lengths, attrition or input is changed.

  Projected inventory updates are provided on request through the 'Update' button.

  Projected TASP gains are displayed only when TASP input for either pipeline is non zero.

  School input optimization

  – Option to enforce school limit

  – Minimum input

  – Maximum deviation

  – Frozen input

  – Option to allow EPA to be exceeded

SKIPPER Scenarios

SKIPPER allows the community manager to develop individual scenarios for different school plans, promotion plans, etc. This provides a convenient way to group different overrides. A different override can be created for each fiscal year for most data, for example, different continuation rate overrides can show planned future changes in SRB policies or school loading.

Conclusion

SKIPPER has proven to be a valuable tool for community managers in developing training and accessions plans. To provide the capabilities needed in the current environment, output produced by SKIPPER could be manually manipulated to produce the needed information. Such ad hoc methods, which would certainly differ across individual managers, have historically produced information which was less credible and more difficult to defend than information derived from the model.

As the next version of SKIPPER, known as ACCORDIAN, is deployed to the community managers, the added dimension of sea/shore rotation will be integrated into the existing skill/paygrade/years of service modeling capabilities.

Appendix A
End Inventory Equation

Appendix A

End Inventory Equation

Let:
E = End Inventory
B = Begin Inventory
N = Net Inventory (End inventory except for planned examined advancements)
G = Gains
L = Losses
ADI = Advancements, pre-Determined In (from paygrade P-1 to P)
ADO = Advancements, pre-Determined Out (from paygrade P to P+1)
AI = Advancements In (from paygrade P-1 to P)
AO = Advancements Out (from paygrade P to P+1)
DI = Demotions In (from paygrade P+1 to P)
DO = Demotions Out (from paygrade P to P-1)
S = Skill
L = Length of Service (1, 2,..., 31)
P = Paygrade (B3, E4, E5, E6, E7, E8, E9)
T = Time interval; forecast fiscal year 1, 2,..., 8 or advancement cycle 0, 1, 2

(1) NSLPT = BLPT + GSLPT - LSLPT + ADISLPT - ADOSLPT + DISLPT - DO SLPT

(2) ESLPT = NLPT + AISLPT - AOSLPT

For the first fiscal year forecast, the begin inventory is from the end of the last fiscal year. For subsequent forecasts, the end inventory from the previous year is the begin inventory for the next.

For the first advancement cycle forecasts (E456, E7 or E89), the begin inventory is from the most recent quarter. The first advancement cycle forecast, "cycle 0", covers the time interval from the date of the database to the beginning of the first advancement cycle to be planned. As with fiscal year forecasts, the end inventory of one forecast is the begin inventory for the next forecast.

(1) The net inventory includes everything but planned examined advancements. Gains are added, losses subtracted, and demotions subtracted from the higher paygrades and added to the lower. "Pre-determined" advancements are those that have already been planned, or are otherwise outside the scope of current policy-making.

(2) End inventory is net inventory plus planned examined advancements added to higher paygrades, and subtracted from the lower.

All internal calculations are made with floating point real numbers. Prior to display, end inventory is rounded to the nearest whole number for each LOS/paygrade. However, the unrounded numbers are used as begin inventory when continuing the forecast for the next fiscal year. This is done to avoid compounding rounding errors. This means that occasionally the user may see what appears to be a slight discontinuity in the forecasts.

Appendix B
Demotions Equation

Appendix B

Demotions Equation

Let:
DO = Demotions Out
DI = Demotions In
B = Begin Inventory
DR = Demotion rates
S = Skill
L = Length of Service (1, 2,..., 31)
P = Paygrade (B3, E4, E5, E6, E7, E8, E9)
T = Time interval; forecast fiscal year 1, 2,..., 8, or advancement cycle 0, 1, or 2

H = Historic time interval (last 12 months)

(1) DOSLPT = BSLPT * DRSPH
(2) DISLPT = Family Split (DOSLPT)

(1) Demotions Out of a paygrade are calculated as a percent of begin inventory, using historic demotion rates.

(2) Demotions Out are then converted to Demotions In to the lower paygrade. For skills that are alone in their family, Demotions In are exactly equal to the Demotions Out from the higher paygrade. But in a multi-skill family, demotions In to one skill may come out of several skills. Conversely, Demotions Out of a skill may go to several skills.

Appendix C
Losses Equation

Appendix C

Losses Equation

Let:

L = Losses
B = Begin Inventory
E = EAOS (at-risk) percent
C = Continuation rates
SRB = Selective Retention Bonus adjustment to at-risk continuation rates
R = Risk category (at-risk for non-reenlistment, non-at-risk for attrition)
S = Skill
L = Length of Service (1, 2,..., 31)
Z = SRB Zone (A, B, C)
P = Paygrade (B3, E4, E5, E6, E7, E8, E9)
T = Time interval; forecast fiscal year 1, 2,..., 8, or advancement cycle 0, 1, or 2
H = Historic time interval (last 12 months)

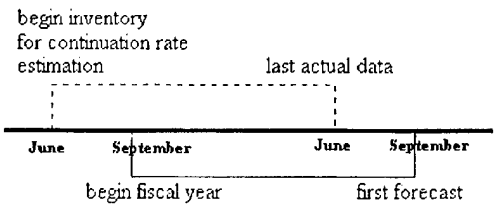
(1) BRSLPT = BSLPT * ESLH
(2) CR=at-riskSLT = CR=at-riskSLH + SRB(Z including L)T, (0 <= CR=at-riskSLT <= 1.0)
(3) LRSLPT = BRSLPT * (1 - CRSLT)
(4) LSLPT = LR=at-riskSLPT + LR=not-at-riskSLPT

(1) Begin inventory is differentiated into inventory which is at-risk and not-at-risk.

(2) At-risk continuation rates are then adjusted to reflect the influence of changes in Selective Retention Bonuses (see Continuation display). The rate adjustments are additive rather than multiplicative, so the model constrains the new rates to be between 0 and 1.

(3) Losses are estimated by multiplying inventory at the beginning of the time interval against the historic loss rate estimate. Loss rates are the complement of continuation rates, by definition.

Continuation rates estimated with data spanning the most recent 12-month interval are used as a basis for calculations. This increases the accuracy of the first forecast substantially, since up to three-quarters of the time interval on which the continuation rates are based has already passed (and so the estimates tend to be very accurate).



Currently continuation rates do not have paygrade detail. However, a new version of SKIPPER planned for the near future will permit overrides of continuation rates with paygrade detail.

(4) Total losses are the sum of attrition and non-reenlistment.

Appendix D
Continuation Equations

Appendix D

Continuation Equations

Let L = LOS 1, 2, 3,..., 29, (30 + 31) (last two LOS cells grouped together)
Let R = Risk category (at-risk/not-at-risk)
Let I = Inventory 12 months prior to most recent quarter
Let S = Survivors (members of I in the same skill, or advanced within the family, 12 months later)
Let C = Continuation rate

CLR = 0 if ILR = 0
else CLR = SLR / ILR

Appendix E
Gains Equations

Appendix E

Gains Equations

Let:

G = Gains
O = Origin of gains (either school gains or non-school gains).
AG = All-Skill gains (summed data for all-skills)
S = Skill
L = Length of Service (1, 2,..., 31)
P = Paygrade (B3, E4, E5, E6, E7, E8, E9)
T = Time interval; forecast fiscal year 1, 2,..., 8
H = Historic time interval; last fiscal year for fiscal year forecasts, last 12 months for cycle forecasts

(1) GOSLPH = Induce(GOSLH, GOSPH, AGOLPH)
(2) GOSLPT = Normalize(GOSLPH, GOST)
(3) GOLPT = GO=schoolSLPT + GO=non-schoolSLPT

Gains calculations are more complicated than for most data types because of a decision to store gains data by LOS and paygrade margins only, rather than storing the complete LOS by paygrade detail. This decision may be reversed in future versions of SKIPPER.

(1) First, full LOS by paygrade detail is obtained from the historic LOS and paygrade margins, using an all-skill matrix to provide a starting point. Note that the accuracy of the all-skill matrix for the particular skill does not really matter. It is the LOS and paygrade margins that are important.

(2) Next, the LOS by paygrade counts are used to distribute the total gains for the fiscal year, which are provided as user inputs from the Gains display sheet.

The Gains display sheet, where managers develop accessions plans, is by fiscal year. For cycle forecasting fiscal year gains are converted to advancement cycle data by the model.

(3) Finally, school and non-school gains are added together for total gains.

Appendix F
Advancements Equations

Appendix F

Advancements Equations

Let:
ADI = pre-Determined advancements In (advancements not subject to planning)
ADO = pre-Determined advancements Out
PR = Prospective advancements
SE = Selectee advancements
M = Miscellaneous advancements
AI = Examined advancements In
AO = Examined advancements Out
TP = Testpassers In
TIS = Time In Service constraints for advancement
S = Skill
L = Length of Service (1, 2,..., 31)
P = Paygrade (B3, E4, E5, E6, E7, E8, E9)
F = Fiscal Month
T = Time interval; forecast fiscal year 1, 2,..., 8, or advancement cycle 0, 1, or 2
H = Historic time interval (last 12 months)

Advancements not subject to planning:

(1) PRSLPT = Accumulate(PRSLPF, T)
or 0 for begin T > last cycle plannedP
(2) SESLPT = Allocate(SESLPH, T)
or 0 for begin T > last cycle plannedP
(3) ADISLPT = PRSLPT + SESLPT + MSLPH
(4) ADOSLPT = FamilySplit(ADISLPT)

Advancements to be planned:

(5) AISPT = VacancyDrivenAdvancements(NSPT, EPASPT, TPSP)
or 0 for end T < last cycle plannedP
(6) AISLPT = ConstrainedDistribution(AISPT, NS1...Sn,LPT, TISP)
(7) AOSLPT = FamilySplit(AISLPT)

Pre-Determined advancements are those that are already planned or are for some other reason unchangeable at the time of the modeling activity. They are included in the calculation of net inventory along with losses and gains.

(1) Prospective advancements are examined advancements that have already been planned, with dates assigned. They are in the database by fiscal month. The forecast model first accumulates the monthly counts throughout the range of the kind of forecast being calculated (fiscal year, E456 6-month cycles, or E7 or E89 12-month cycles). Prospectives are planned for all the paygrades through some month. If the forecast interval starts after that month, then there are zero prospectives.

(2) Selectee advancements are examined advancements that have already been planned, but which do not yet have dates assigned. These are distributed across the time interval between the last month for which prospective

advancement dates have been assigned, and the last month of the advancement cycle that was planned. These intervals depend on the paygrade (see Aging Inventory for Cycle Forecasts). Monthly counts of advancements, from the SPAN model, are used to distribute the selectee advancements over these intervals. At times advancement policy, as reflected in the data from SPAN, causes the distribution of advancements to be highly non-uniform (specifically, they sometimes are done almost entirely in the last month of the advancement cycle). As for prospective advancements, once the forecast calculations have progressed beyond the period for which advancements have been planned, selectees are zero.

(3) Total pre-determined advancements IN are then the sum of prospectives, selectees and miscellaneous advancements. Note that automatic advancements are not included. This is because there is a very large overlap between automatic advancements and school gains (almost all automatic advancements are also school gains). The SKIPPER model therefore does not use automatic advancements in its calculations.

(4) Pre-determined advancements IN are then converted to pre-determined advancements OUT. For skills that are alone in their family, advancements OUT are exactly equal to the advancements IN to the higher paygrade. But in a multi-skill family, advancements IN to one skill may come out of several skills. Conversely, advancements OUT of a skill may go to several skills.

(5) Examined advancements are those that are being planned for future advancement cycles. A vacancy-driven algorithm compares net inventory to target inventory, and generates the advancements necessary to meet the targets. Advancements are generated by paygrade, without LOS detail. Testpassers serve as an upper bound—advancements into a skill are not permitted to exceed the number of testpassers available.

Enlisted members take the advancement test for a particular cycle. So if the forecast is for an advancement cycle, the number of testpassers to use is very straightforward, for the paygrades being planned. However, for fiscal year forecasts and for the paygrades not being planned for advancement cycles, testpasser counts must be adjusted. For fiscal year forecasts, historic testpassers for the last E7 and E89 12-month cycles are used. The difference in timing between these advancement cycles and the fiscal year is disregarded. For paygrades E456, historic testpassers for the last two 6-month cycles are added, again disregarding differences in timing. For paygrades not being planned for advancement cycles, more elaborate adjustments must be made.

(6) Examined advancements by paygrade are then distributed by LOS so that they may be added into the end inventory. The net inventory at the lower paygrade is used for this distribution. Only LOS within the range of Navy Time in Service requirements are considered. In other words, it is assumed that all members with a LOS satisfactory to be in the upper paygrade are equally likely to be advanced. If the forecast interval crosses a fiscal year boundary, LOS is aged; the Time in Service constraint applies to inventory after it has joined the end inventory, including aging.

Time in Service constraints in effect are:

Paygrade In	Minimum LOS after adding to end inventory
E4	2
E5	3
E6	6
E7	10
E8	14
E9	16

In addition, SKIPPER guarantees that end inventory counts are non-negative, by constraining advancements to be no greater than net inventory. When advancements are limited by net inventory, a warning is provided to the manager. Generally this occurs when gains, as provided by user input, are below realistic levels.

(7) Examined advancements IN are then converted to examined advancements out. For skills that are alone in their family, advancements OUT are exactly equal to the advancements IN to the higher paygrade. But in a multi-skill family, advancements IN to one skill may come out of several skills. Conversely, advancements OUT of a skill may go to several skills.

Appendix G
Vacancy-Driven Advancements Algorithm

Appendix G

Vacancy-Driven Advancements Algorithm

The vacancy-driven advancement algorithm compares net inventory to target inventory, and generates the advancements necessary to meet the targets as closely as possible. However, advancements must be non-negative, and cannot exceed available testpassers.

Vacancies are first calculated for paygrade E9, then for paygrades E8 down to E4. To determine the number of advancements required, cumulative vacancies are calculated, in which the current paygrades vacancies are added to those of all higher paygrades. This is because the Navy is an agricultural organization. Members rise through the ranks, they do not enter at higher paygrades from the outside. So if 10 members are advanced from E8 to E9, and 20 slots are empty at E8 before advancements out to E9, then 30 advancements into E8 are required.

Hypothetical Example of Calculating of Advancements:

PG	Net Inv	Target	Vacancies	**Cum Vac**	Test Pass	Exam Adv
E9	50	60	10	**10**	12	10
E8	100	120	20	**30**	25	25
E7	200	160	-40	**-10**	40	0
E6	400	500	100	**90**	150	90
E5	500	600	100	**190**	180	180
E4	400	500	100	**290**	400	290

The effect of using cumulative vacancies is to create carrydown. In carrydown, exceeding, or falling short of, target inventory at the next lower paygrade compensates for a shortage or surplus at one paygrade. Carrydown may be either positive, in which a shortage at one paygrade means more advancements into the lower paygrade; or negative, in which a surplus at one paygrade causes less advancements into the lower paygrade. In the hypothetical example above, negative carrydown occurs from paygrade E7 to E6. Note that in terms of readiness, carrydown makes sense, since members a paygrade lower or higher than that ideally desired can generally carry out higher or lower paygrade duties when required.

Distribution List

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